TEST REPORT

H-115, S/N: 031

250 kHz x 64 mm Diameter Focused Transducer

and

Fundamental Resonance Impedance Matching Network

California Institute of Technology

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Overall Conformity

Date: 12/12/2018

Conformity: Yes

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I. Transducer Specifications

Center Frequency	Fundamental: 250 kHz Tuned to: 333.8 kHz
Active Diameter	64.00 mm (2.520 inches)
Geometric Focus	63.2 mm (2.488 inches) = radius of curvature at radiating surface
Pressure Focal Gain	Fundamental mode: 12.17 (assumes 1 at the radiating surface and in a linear homogenous field)
Focal Depth	51.74 mm (2.037 inches); measured from exit plane of transducer housing rim to geometric focus
# of Elements	1
Environment	Immersible in water to a depth of 0.5 meter, 0 to 60 ^{o}C
Cable	RG-58 50 Ohm coax, exits housing on side, 0.5 meter length
Connector	BNC male on transducer cable; BNC female connectors on both sides of matching network.
Transducer Housing	Stainless steel, 3.250 inches diameter x 1.000 inch high
Mounting Holes	Six tapped blind holes on rear of housing, 6-32 x 0.40 inch deep for mounting to tanks or fixtures
RF Shielding	Transducer housing is RF shielded. Conductive transducer face and RF shield are connected to cable ground return.
Matching Network	A fundamental RF impedance matching network is supplied inside an external enclosure, intended for use with a 50 Ohm RF amplifier.

II. Burn-in Test (if applicable)

Not applicable

III. Electrical Impedance*

* Test is performed proceeding burn-in test (if applicable for this specific transducer).

An HP 4194A Impedance/Gain-Phase Analyzer was used to measure the electrical input impedance of the transducer. During these measurements, the transducer face was in room-temperature water with no reflectors. In the attached plots, the transducer impedance is shown at the fundamental and third harmonic with and without the RF matching network.

- Degassed water at 20 degrees Celsius
- Non-reflective environment
- Fundamental (Fo) plotted frequency range: 0.100 kHz to 500 kHz
- Impedance magnitude (Z): Plotted from 0 to 300 Ohms
- Phase: Plotted from -90 to +90 degrees

<u>FUNDMENTAL RESONANCE MODE (see Appendix for Figures)</u>

Operating Band down to -3 dB normalized to a perfect 50 Ohm / 0 degree match:
(See Power Transfer plot, Figure 2)

Center Frequency	333.8 kHz
Minimum Frequency	248.8 kHz
Maximum Frequency	360.0 kHz

Unmatched electrical impedance values @ Center Frequency

	Magnitude (Ohms)	Phase (degrees)
@ Center Frequency	237.973	-78.983

Matched electrical impedance values over operating band:

	Magnitude (Ohms)	Phase (degrees)
@ Center Frequency	61.211	15.869
Minimum	21.101	-71.966
Maximum	83.563	63.901

IV. Power Input at Center Frequency

<u>FUNDAMENTAL RESONANCE MODE</u>

	Watts Electrical	Pressure at Surface (kPa_peak)	Voltage (Vrms)	Current (Irms)
Max Pulsed	1000	833	1116	NA
Max Average	500	589	789	3.3

V. Beam Pattern Measurements

No beam pattern measurements were made for this specific transducer. This transducer is similar to a previous transducer, which has been measured. The transverse focal width at half-amplitude (the so-called “FWHM”, or width at -6 dB points) and the axial focal length were in close agreement with theoretical beam pattern calculations.

Theoretical values	Focal Width (mm)	Focal Length (mm)
Fundamental	4.52	30.77

VI. Usage Notes

The transducer is coated with a thin film of epoxy. The housing is stainless steel. The transducer face, housing, and cable exit are water-tight. The transducer interior air space is vented to atmosphere through the tubing that surrounds the coaxial cable.

The transducer face and housing are at RF ground potential. Due to the large RF present within the transducer during operation, an **electrical safety ground** connection to the transducer housing is highly recommended. If the transducer were broken during operation, the internal RF electrical wires could come into contact with the water, presenting an electrical shock hazard.

Permanent damage could result if the transducer is dropped, particularly if the face strikes a solid object. The transducer face is quite brittle. Use extreme care when handling the transducer.

Permanent damage could also result if the transducers are overheated. Internal temperatures to 80^{o}C should not cause permanent damage, but this is difficult to determine from external temperature measurements. Avoid driving the transducer at high power at frequencies far away from the center frequency, because the transducer is much less efficient at frequencies away from resonance.

Hazardous RF voltages also exist within the impedance matching network during operation. The network should not be driven at high power with the cover removed.

The matching network will only function correctly if it is connected **directly** to the transducer, with **no** added cable length. The cable length between the RF amplifier and the transducer should not have a significant effect on performance. Due to the high power levels, the current in the cable is fairly high and cable heating could be significant. During sustained high-power operation, the temperature of the cable between the matching network and transducer should be periodically checked. Operation at frequencies away from the center frequency may result in higher resonant currents in the cable, and thus higher cable heating.

The matching network is fairly robust, but they could be damaged if dropped on a hard surface. If damage is suspected to either the matching network or the transducer, a simple test can be performed with your RF wattmeter. Simply drive the transducer at its center frequency (in water with no reflections) and check forward and reflected power. If the input impedance is still 50 Ohms and close to zero degrees, then there will be minimal reflected power. If damage has occurred, the impedance is likely to have changed.

For operation at sustained high-power levels, airflow should be supplied to the matching network. The built-in fan operates at 12 VDC. Reduced voltages may be used while operating at intermediate power levels or moderate duty cycles, due to reduced cooling requirements.

Appendix

Figure 1.a. Electrical impedance, fundamental resonance without matching network:

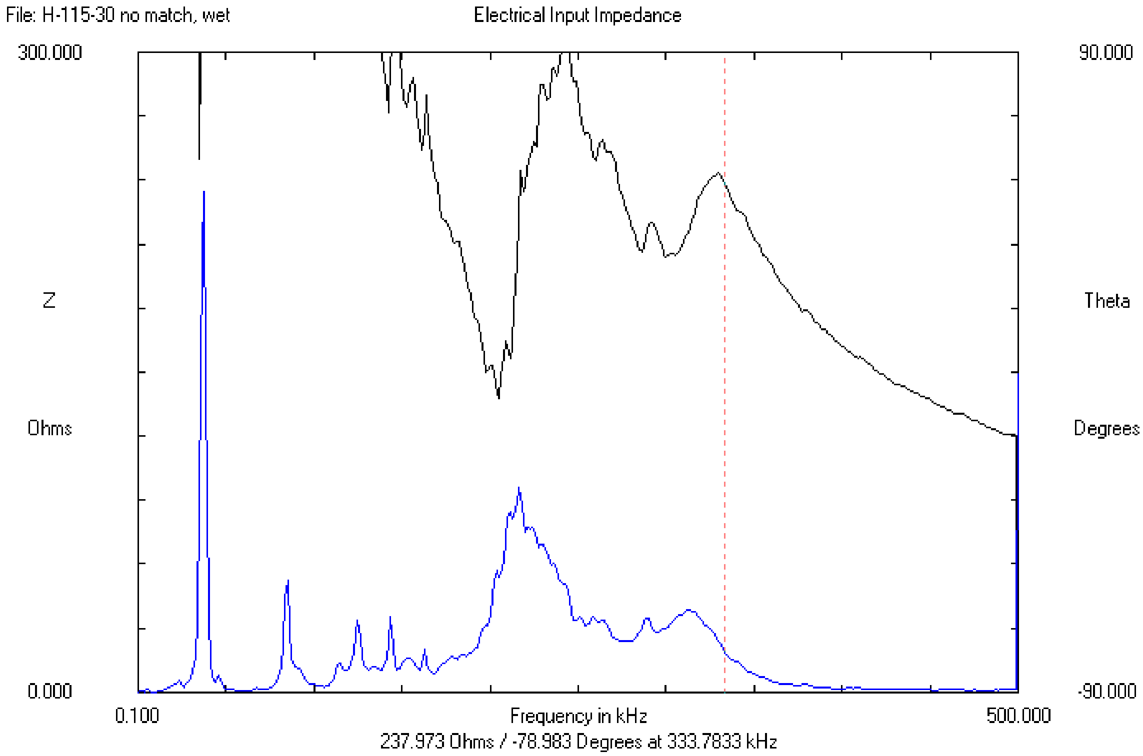

Figure 1.b. Electrical impedance, fundamental resonance with matching network:

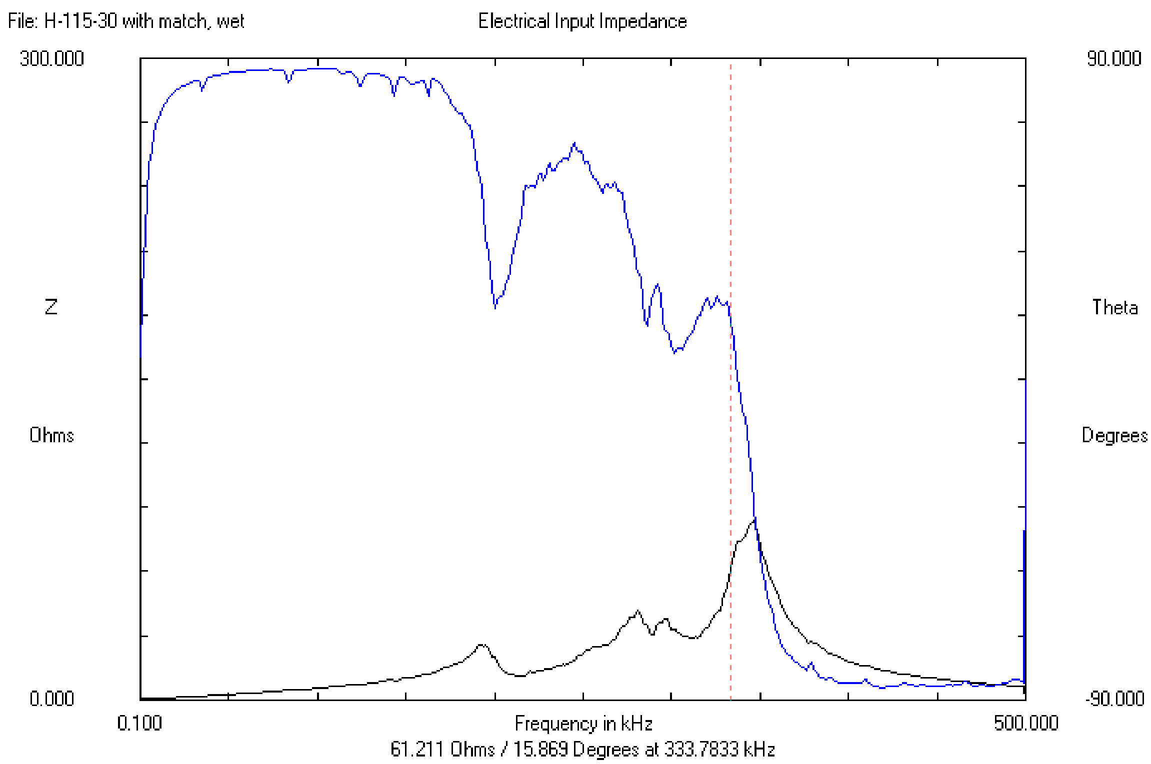

Figure 2.a. Power Transfer relative to 50 ohm perfect load, fundamental mode